

under 35 USC 103 as unpatentable over Wedel in view of Wywailowski et al and further in view of Skaugen et al. Claims 18-21, 28 and 29 stand rejected under 35 USC 103 as unpatentable over Walker in view of Wells.

For the reasons set forth in detail below, it is respectfully submitted that the claims presently active in this application patentably define over the teachings of the prior art references and are allowable.

The present invention relates to methods and apparatus for reducing the tendency of paper to curl. As set forth in the specification, the reduction in the tendency of paper to curl has become more important with new printing and copying methods in which paper is subjected to sudden heating from a single side. Such heating results in internal strains remaining in the paper manifesting themselves causing the paper to curl. The tendency of paper to curl results not only from structural properties of the paper, but also by anisotropies produced in the thickness direction of the paper during drying. Thus, in modern single-wire draw drying sections, the paper web is not dried symmetrically. Rather, the drying effect is applied more extensively to the surface or side of the paper that is in direct contact with the heated drying cylinders. The drying of the opposed sides of the web in single-wire draw drying sections cannot be accomplished at the same rate thereby resulting in internal strains being set up in the thickness direction of the paper web.

Attempts have been made to eliminate the anisotropies produced in the thickness direction of the paper web by unequal drying rates by means of providing every second

group of drying cylinders to be a "inverted" group in which the steam-heated drying wires are situated in the lower row while the lead-in cylinders are in the upper row. In this manner, the bottom side of the web will be in direct contact with the heated drying cylinder surfaces in one group whereupon the top side or surface of the web will be in contact with the heated surface of the drying cylinders in the next, inverted group. However, the use of inverted drying groups gives rise to difficulties in the removal of broke since the free sectors of the drying cylinders do not open downwardly as is the case in normal drying groups but, rather, form pockets that are closed at the bottom.

The present invention provides methods and apparatus for reducing the tendency of paper to curl without the need for inverted drying groups (although inverted drying groups may of course be used in addition to the invention).

In accordance with the invention as defined in independent claims 1 and 22, and new independent claim 30, a method for reducing the tendency of paper to curl comprises raising the temperature of the bottom side of the web after it has separated from the heated face of a drying cylinder by applying steam to the bottom side of the web to thereby control the moisture gradient in the thickness direction of the paper web between the paper web sides. The steam treatment is applied to an open face of the bottom side of the paper web.

Independent claim 8 specifies that the steam box arranged in the drying group constitutes "means for controlling the moisture gradient created in the thickness direction of the paper web between the paper web surfaces" so that the tendency of the paper web

to curl is prevented. Independent claim 18 specifies that the steam is applied to the bottom side of the web "to control the moisture gradient in the thickness direction of the paper web between the paper web size" to thereby control curling of the web.

None of the cited prior art references teach or even suggest the method or apparatus of the present invention.

Wedel (U.S. 4,876,803) merely discloses the use of a vacuum transfer roll between a pair of drying cylinders to reduce the tendency of the web to separate from the drying felt during movement around the transfer roll. Wedel is manifestly devoid of any teaching or suggestion relating to reducing the tendency of a paper web to curl.

Wywailowski et al. (U.S. 4,662,398) relates to the structure of a valve for a steam box which is used for adjusting the moisture profile of a paper web in the cross machine direction in order to provide uniform coating characteristics for the paper web. The patent discloses the use of the steam box in "a web drying machine" and it is by no means clear from Wywailowski et al. that the steam box is used in the drying section of a paper machine. In any event, Wywailowski et al. controls the moisture profile of a paper web in the cross machine direction. By controlling the cross machine direction web moisture content, a higher percentage of moisture can be allowed in the salable roll of paper and uniform coating characteristics are promoted. Wywailowski et al. is manifestly devoid of any teaching or suggestion regarding the reduction in the tendency of paper to curl through controlling the moisture gradient in the thickness direction of the paper web between the paper web sides.

Thus, neither Wedel nor Wywailowski et al., taken either alone or in combination, suggest that after the bottom side of a web which is in direct contact with the heated surface of a drying cylinder separates from that heated face of the drying cylinder, raising the temperature of the bottom side of the web is raised by applying steam onto the bottom side of the web to control the moisture gradient in the thickness direction of the paper web to thereby reduce the tendency of the paper to curl.

Similarly, Walker (U.S. 4,378,639) is concerned with the moisture profile of a web in the transverse or cross-machine direction of the web in order to eliminate wet or dry streaks in the web. Walker, like Wedel and Wywailowski et al., is totally silent with respect to methods or apparatus for reducing the tendency of paper to curl by increasing the temperature of the bottom side of the web after it separates from the heated face of a drying cylinder to thereby control the moisture gradient in the thickness direction of the paper web.

Furthermore, Wells (U.S. 4,249,992) also has nothing to do with the present invention. Wells discloses a construction for a steam box for adjusting the application of steam to a web with a view to providing a more uniform transverse or cross-machine moisture profile.

It is seen from the foregoing that not a single one of the cited references suggests an arrangement in which curling of paper can be reduced by means of a steam box placed in a drying section which raises the temperature of the bottom side of the web

after it separates from the heated surface of the drying cylinder to thereby control the moisture gradient in the thickness direction of the paper web.

New claim 30 further specifies raising the temperature of the bottom side of the web after it has separated from the heated face of the drying cylinder and after its temperature has decreased below the temperature of the top side of the web to a temperature above the top side of the web by the application of steam to the bottom side of the web to control the moisture gradient in the thickness direction of the web. As seen in Fig. 5a, and as discussed at page 15 of the specification, through this method the difference in temperature between the two faces of the web equalizes rapidly after the temperature of the bottom side has been raised above the temperature of the top side. The equalization in the temperatures tends to eliminate the internal strains which would otherwise be set up in the thickness direction of the paper web. Clearly, none of the cited prior art references teach or suggest this method.

All of the remaining claims depend either directly or indirectly from the independent claims discussed above and therefore contain the various limitations thereof. Accordingly, for the same reasons as advanced above relative to the independent claims, the dependent claims are also deemed to be allowable.

The Examiner has objected to the Amendment filed September 20, 1993 taking the position that it introduces new matter into the specification. Claims 14 and 15 have been cancelled in order to overcome this objection.

In view of the foregoing, it is respectfully submitted that this application is presently in condition for allowance and early passage to issue is respectfully solicited.

A Petition For One Month Extension accompanies this Amendment.

Respectfully submitted,

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